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Hengeveld, R.; Reydon, T.A.C.

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EDITORIAL

Editorial: A New Turn in the Study of the Origin of Life

Rob Hengeveld · Thomas A. C. Reydon

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The last couple of decades have seen an increasing interest in the way life could have originated. The interest in this problem is itself neither new, nor restricted to this particular period; the interest of scientists in extraterrestrial life dates as far back as Christian Huygens in the 17th century, whereas scientific considerations on a terrestrial origin began around 1900. In the 1950s, experimental analysis was initiated by Miller's electric discharges into a mixture of gas, similar to that supposed to have existed both in outer space, and possibly also on Earth. After Wöhler's experiments on ureum in the 19th century, showing that organic molecules could be experimentally made, Miller's work suggested that even life as such could be subject to experimental analysis, once its possible origination could be understood.

The following decades elaborated on this theme, the experiments being mainly designed and carried out by chemists. The questions posed centred on whether it would be possible to reproduce compounds that are common in cells as we know them, and also of pivotal importance for them. For example, after Miller's discovery of amino acids in the chemical broth he produced, Oro's subsequent experiments on nucleic acids from simple carbohydrates concentrated on ribose and nucleosides, such as adenine. Miller's experiments were initiated by the astronomer Urey, and later astronomers were able to find amino acids and adenine in outer space, as well as a rapidly increasing number of other organic compounds also known from living cells. Actually, the analysis of nucleic acids brought in another aspect that had come more to the fore in the same period, the chemical basis of the information system of DNA studied by Eigen. This aspect of an

R. Hengeveld (✉)
Institute of Ecological Science, Vrije Universiteit, De Boelelaan 1087, 1081 HV Amsterdam, The Netherlands
e-mail: rhengeveld@wish.net

T. A. C. Reydon
Center for Philosophy and Ethics of Science (ZEWW), Leibniz University of Hannover, Im Moore 21, 30167 Hannover, Germany
e-mail: reydon@ww.uni-hannover.de

information system found in the living cell introduced the idea of a biochemical system. Not only the chemical causation of these systems, but their biological functions were of interest. This idea of a metabolic system can be found in Morowitz's early work on the thermodynamic background of metabolic cycles, this thermodynamic background of life being later emphasized by the physicist Prigogine. Again, more recently, the cytologist de Duve brought together the rapidly increasing knowledge of the biochemistry and functional organisation of cells under the heading of life's origination, combining this with new thermodynamic insight.

Meanwhile, knowledge of the history of the universe, the solar system, and the Earth itself was growing rapidly as well. The Sun proves not to be the only star with planets, but about 150 other stars have also been found to be accompanied by planets. A growing knowledge of the Moon and the planets in our own solar system led to a better understanding of the astronomical and chemical history of the Earth. This was supplemented by new insight into the geochemical development of the Earth, its oceans and the atmosphere. Some geochemical models, for example those of Holland and Kasting, were integrated with models on early life. Finally, the ground-breaking work of Williams and Fraústo da Silva on the relevance of inorganic chemistry for living systems, the operation of which put many structures and processes into historical perspective. This approach was picked up by the palaeontologist Knoll, combining these ideas with those of the soil scientist Canfield, thereby following in the footsteps of the Precambrian palaeontologist Cloud.

Yet, all these activities, with their rapidly growing understanding issuing from an hitherto unheard of integration of many disparate scientific fields, seemed to go largely unnoticed by biologists. The study of the origin of life, essential to an understanding of life as such, belongs mainly to astronomers, physicists, chemists, geochemists, and biochemists, plus some geologists and palaeontologists. So far, biological theory and methodology have not been included in this new, integrated study of biogenesis. Perhaps because of its development outside biology, the emphasis is still on understanding of the astronomical origin or the chemical formation individual chemical compounds, rather than on their biological evolution and their functional integration into cells as living systems.

The present issue of *Acta Biotheoretica* is a special issue of the journal that focuses on the topic of the origin of life. It contains three papers that follow a different, systems theoretical approach based on thermodynamic principles. The authors attempt to integrate such a thermodynamic systems approach with the findings and new understanding of biogenesis from the various fields mentioned. Russell, moreover, has started experimental work along these new lines, whereas Fedonkin and Hengeveld are postponing such an analysis until their understanding of some basic processes has deepened further. In this context, it seemed appropriate to Hengeveld to analyse the differences between this new approach and current biogenetic research in order to evaluate the perspective that the new approach gives.

We are greatly indebted to the external referees who have evaluated the articles contained in this issue of *Acta Biotheoretica* and have provided extensive comments and suggestions for improvement. We hope that the publication of this special issue on the origin of life will help to stimulate further experimental and theoretical investigation into this fascinating topic.